Efficacy of Blood Hemoglobin Concentration as an Indicator of Pork Quality

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Introduction:

Pork Consumption

One of the most important aspects of a meat product that influences a consumers' decision during the initial purchase is the product's appearance. The first impression the product offers is its color. It is generally recognized that pork cuts with darker color and increased amounts of marbling tend to have a higher pH and thus, result in a more desirable eating experience (Aberle *et al.* 2001). The pork industry's goal is to improve production efficiency and to simultaneously produce a high quality product that will result in increased consumer demand and market share (Brewer, 1998). In order to have success with marketing, consumers need to like what they see and have a desirable eating experience which will result in repeated purchases.

The color of meat is directly related to the concentration of myoglobin present in the muscle. Myoglobin is considered the pigment in muscle and its biological function is to bind and store oxygen (Aberle *et al.* 2001). The oxygen is transported to the myoglobin via the vascular system. This oxygen is then used during aerobic respiration of the muscle during ATP synthesis via the Kreb's Cycle. Oxygen is transported in the blood by hemoglobin. Therefore, hemoglobin carries oxygen to the myoglobin; and myoglobin concentration can impact fresh meat quality. There could be a correlation between hemoglobin concentration and fresh pork quality.

The previous research in this area does not address the relationship between hemoglobin concentration and its contribution to fresh meat quality. This research investigated the relationship between hemoglobin concentration and fresh pork quality characteristics. As mentioned earlier, fresh pork quality encompasses appearance and palatability. Palatability is described as taste/flavor, juiciness, and tenderness. If hemoglobin concentration is correlated with pork quality, then a simple, inexpensive hemoglobin test could be implemented as a genetic selection tool to improve pork quality without sacrificing the animal.

Materials and Methods:

Swine of four different genetic backgrounds were evaluated in this study including: Purebred Landrace, Purebred Berkshire, and first cross (F1) offspring of Landrace sires mated to Berkshire dams and the reciprocal Berkshire sires mated to Landrace dams. Offspring were raised in a hoop structure at the Ohio Agricultural Research and Development Center's Western Research Station. The offspring of these matings were harvested at end-point age and weight targets consistent with U.S. swine industry markets. At harvest, blood samples were collected and hemoglobin concentration measured using a Hemocue Hb 201 measurement device (Hemocue AB, Angelholm, Sweden).

24 h Postmortem Data Collection

After the carcass chilled for 24 hours, carcass data was collected. The carcass was ribbed at the 10^{th} rib location for composition and muscle quality trait assessment by trained personnel. The exposed loin face was allowed a 10 minute bloom period.

After bloom, the loin muscle was subjectively evaluated for surface wetness (WET), marbling (MARB), color (COLOR), and firmness (FIRM) following guidelines described in Pork Composition and Quality Assessment Procedures (NPPC, 2000). Loin muscle area (LMA) was assessed using a grid overlay and backfat thickness (BF) was assessed at the ¾ location with a steel ruler. The same face was also instrumentally evaluated for Minolta L* and a* using a Minolta CR-310 chromameter (Konica Minolta, Ramsey, NJ) fitted with a 50 mm optical probe and calibrate with D65 illuminant against a white tile and for 24 h pH.

24 h Postmortem Data and Sample Collection

At 24 h post mortem, the carcasses were processed to obtain chops for intramuscular fat (IMF), purge loss (PURGE), cook loss (CLOSS), and Warner-Bratzler shear force (WBS) analyses. Immediately posterior to the 10^{th} rib split of the carcass left side, a 1.27 cm chop was cut with a bandsaw and dissected free of any visible subcutaneous fat and epimysial tissue and vacuum-packaged and frozen at -20^{o}C until analysis of IMF. Immediately posterior to the 1.27 cm chop, a 2.54 cm chop designated for PURGE analysis was cut with a bandsaw, trimmed of bone and excessive subcutaneous fat, weighed, and vacuum-packaged. The chop was further aged at 4^{o}C for a period of 7 days postmortem. After aging, the chop was removed from the package, freed of any excessive surface exudates, and re-weighed. PURGE was recorded as the percentage of weight loss of the fresh chop due to exudate.

Immediately posterior to the 2.54 cm chop, two 5.08 cm chops, each designated for CLOSS and WBS analyses, were cut with a bandsaw and vacuum-packaged. The

anterior chop, which attained a 3 day postmortem period of aging, was immediately frozen. The posterior chop was aged at 4°C for a period of 7 day postmortem, at which time it was also frozen until further analysis.

CLOSS and WBS Analysis

Prior to CLOSS and WBS evaluation, the frozen 5.08 cm chops were removed from the packaging and a 2.54 cm chop was cut from the central portion using a bandsaw. This method of cutting while in the frozen state allowed for greater precision and uniformity in cutting of the chops. The 2.54 cm chops were laid flat in a single layer, covered, and allowed to thaw at 4°C overnight. Once thawed, the chops were trimmed of bone and excessive subcutaneous fat. The chop was cooked at 190°C in a Lincoln impinger over (Model 1132-000-A, Lincoln Foodservice Products, Inc., Fort Wayne, IN) to a target internal temperature of 71°C. Weights were recorded on individual chops immediately before and after cooking. CLOSS was recorded as the percentage of weight loss of the chop during cooking.

Cooked chops were allowed to cool to room temperature prior to tenderness evaluation. Six 1.27 centimeter cores were cut parallel to the muscle fascicles. Individual cores were transversely sheared at a cross-head speed of 3.33 mm/s with a Warner-Bratzler probe attached to a Stable Micro Systems TA.XT.Plus Texture Analyzer (Texture Technologies Corp., Scarsdale, NY). WBS was recorded as the average peak shear force (kg) exerted over six cores.

IMF Analysis

A chemical analysis of intramuscular fat content (IMF) was performed on the frozen 1.27 cm chop previously described using an Ankom^{XT20} Fat Analyzer linked to an Ankom^{XT} Recovery System (Ankom Technology, Fairport, NY). Muscle tissue was extensively homogenized in a commercial food blender at high speed for a short period of time. Approximately 1.8 g of the homogenate was sampled, sealed in an Ankom^{XT4} Filter Bag (Ankom Technology, Fairport, NY), and dehydrated overnight in a 100^{o}C oven. Samples were weighed, extracted in petroleum ether (Fisher Scientific, Fairlawn, NJ) for 45 minutes at 90^{o}C, dried in a 100^{o}C oven for 30 minutes, and reweighed. IMF was recorded as percentage of homogenate sample extracted as fat (wt/wt) and was expressed on a wet matter basis. A minimum of two samples per chop were independently extracted and the reported IMF was the average of the repeat analyses.

Statistical Analysis

Statistical analysis was conducted using SAS 9.1 software (SAS Inst. Inc., Cary, NC). An analysis of variance was conducted using the GLM procedure. Dependent variables analyzed included backfat, loin muscle area, hemoglobin content, loin pH, loin color, loin marbling, loin Minolta L* and a*, and Warner-Bratzler Shear force. Independent variables included genetic type (purebred Landrace, Landrace x Berkshire, Berkshire x Landrace, and purebred Berkshire), pig gender, and a random effect for harvest date. Relationships between traits were assessed after adjusting for independent variables and reported as residual correlation coefficients.

Results

When all of the data was collected, genetic line differences were observed for composition and quality traits (Table 1). Purebred Berkshire pigs were lighter weight and had less muscle than the crossbred or purebred Landrace genetic lines at harvest, while purebred Landrace pigs had less backfat. Purebred Landrace pigs produced loins that were paler in color, lower in loin pH, and tougher as measured by Warner-Bratzler Shear force. In contrast, loins from Berkshire and Berkshire crossbred pigs were generally darker, with greater marbling and pH, and were more tender as measured by Warner- Bratzler Shear force. The blood hemoglobin concentration from these different genetic lines did not differ significantly.

Table 2 shows that residual correlations between carcass and loin quality traits had very few significant relationships. The blood hemoglobin concentration at harvest did not correlate with subjective (Loin Color) or objective (Minolta L* and a*) color measurements recorded 24 hours postmortem. Blood hemoglobin did have a moderate (r=0.23) positive relationship with Warner-Bratzler Shear force. This indicates that the greater the Hemoglobin concentration, the greater the shear force.

Table 1. Least squares means for carcass and loin muscle quality traits across genetic types at standard harvest weight and age.

		Trait									
Genetic Type	N	Live Weight (kg)	Backfat (cm)	Loin Area (cm^2)	Loin Color	Loin Marbling	Loin Minolta L*	Loin Minolta a*	Loin pH	Blood Hemoglobin	Warner Bratzler Shear (kg)
Berkshire	32	111.2^{c}	3.07^{bc}	33.9^{b}	3.08^{a}	2.88^{a}	54.2^{a}	16.3^{a}	5.72^{a}	13.24	2.11^{a}
Berk x Land	20	128.3^{a}	3.31^{c}	38.5^{a}	2.72^{ab}	1.57^{c}	55.0^{a}	16.5^{a}	5.54^{bc}	13.68	2.47^{b}
Land x Berk	28	121.3^{b}	2.91^{ab}	38.9^{a}	2.69^{b}	1.79^{b}	54.1^{a}	16.2^{a}	5.59^{b}	13.46	2.11^{a}
Landrace	32	119.9^{b}	2.62^{a}	40.0^{a}	1.70^{c}	1.25^{c}	58.5^{b}	14.6^{b}	5.53^{c}	13.11	2.71^{c}
Pooled Std Error		± 1.8	± 0.14	± 0.8	± 0.13	± 0.20	± 0.5	± 0.2	± 0.02	± 0.24	± 0.08

^{abc} Least squares means within a column and harvest without common superscripts are different ($P < 0.05$).

Table 2. Residual correlations between pork carcass composition and pork loin quality traits at standard harvest weights adjusted for breed and gender of pig and variation in harvest date (N = 112).

	Trait[a]							
	Backfat	Loin Area	Loin Color	Loin Marbling	Minolta L*	Minolta a*	Loin pH	Blood Hemoglobin
Loin Area	-0.26*	--						
Loin Color	0.18	-0.14	--					
Loin Marbling	0.22*	-0.16	0.21*	--				
Minolta L*	-0.03	0.00	-0.69*	-0.08	--			
Minolta a*	0.22*	-0.08	0.30*	-0.13	-0.34	--		
Loin pH	0.00	-0.15	0.30*	-0.02	-0.35*	-0.07	--	
Blood Hemoglobin	0.08	-0.05	-0.03	-0.13	-0.09	0.04	-0.02	--
Warner Bratzler Shear	0.08	0.22*	-0.08	-0.10	0.15	0.11	-0.21*	0.23*

* Residual correlation coefficients different from zero ($P < 0.05$).

Conclusions

The results do not prove the hypothesis. Blood hemoglobin concentration collected prior to harvest was not an accurate indicator of pork loin quality in genetic lines of pigs observed to have significant variation in traits currently used by the swine industry to assess fresh pork quality and predict subsequent eating quality. Since hemoglobin does not correlate to fresh pork quality, the use of hemoglobin concentration as a predictor of pork quality in live pigs and as a tool for selection of replacement breeding swine would not be effective.

References Cited

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